$\Delta p = p_f - p_i$

Name:_____

Honors Physical Science
Momentum and Impulse Problems

$p = mv$ $I = Ft$ $\Delta p = Ft$ $mv_{initial} = mv_{final}$

momentum impulse conservation of p

1. Jennifer, who has a mass of 50.0 kg, is riding at 35.0 m/s in her red sports car when she must suddenly slam on the brakes to avoid hitting a deer crossing the road. She strikes the air bag, that brings her body to a stop in 0.500 s. What average force does the seat belt exert on her?

$m = 50.0$ kg
$V = 35.0$ m/s
$t = .500$ s

$p = m \cdot v$
$= 50 \cdot 35.0$
$p = 1750$ kg·m/s

$\Delta p = -1750$ N·s
$t = .500$ s

$F = \frac{\Delta p}{t}$ $= \frac{-1750 \text{ kg·m/s}}{.5 \text{ s}}$ $F = 3500$ N

If Jennifer had not been wearing her seat belt and not had an air bag, then the windshield would have stopped her head in 0.002 s. What average force would the windshield have exerted on her?

$\Delta p = 1750$ kg·m/s
$t = .002$ s

$F = \frac{\Delta p}{t} = \frac{1750}{.002}$ $F = 875{,}000$ N

same Δp

2. A hockey player applies an average force of 80.0 N to a 0.25 kg hockey puck for a time of 0.10 seconds. Determine the impulse experienced by the hockey puck.

$F = 80.0$ N
$t = .10$ s

$I = Ft$ $= 80.0 \text{ N} \cdot .10 \text{ s}$ $I = 8.0$ N·s

3. If a 5-kg object experiences a 10.-N force for a duration of 0.10-second, then what is the momentum change of the object?

$F = 10.0$ N
$t = .10$ s
$\Delta p = ?$

$\Delta p = Ft$ $= 10 \cdot .1$ $\Delta p = 1.0$ kg·m/s

total Δp

4. In a physics lab, 0.500-kg cart (Cart A) moving rightward with a speed of 92.8 m/s collides with a 1.50-kg cart (Cart B) moving leftward with a speed of 21.6 m/s. The two carts stick together and move as a single object after the collision. Determine the post-collision speed of the two carts.

Cart A
$m = .5$ kg
$v = 92.8$ m/s →
$p = 46.4$

Cart B
$m = 1.50$ kg
$v = 21.6$ m/s ←
$p = -32.4$

Before → After

total $p = 14$ kg·m/s

$p = 14$ kg·m/s
$m = (1.50 + .5) = 2$ kg
$V = ?$
$V = \frac{p}{m}$ $\frac{14 \text{ kg·m/s}}{2 \text{ kg}}$ 7 m/s

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5. A 25.0-gram bullet enters a 2.35-kg watermelon and embeds itself in the melon. The melon is immediately set into motion with a speed of 3.82 m/s. The bullet remains lodged inside the melon. What was the entry speed of the bullet?

Before

Bullet: $m = 25.0\ g = .025\ kg$, $p = 9.07\ kg \cdot m/s$

Melon: $m = 2.35\ kg$

$V = \frac{p}{m} = \frac{9.07}{.025}$

$V = 362.8\ m/s$

After

B + M: $m = 2.375\ kg$, $V = 3.82\ m/s$

$p = (2.375 \cdot 3.82) = 9.07\ kg \cdot m/s$

← Same p ←

6. A 25.0-gram bullet enters a 2.35-kg watermelon with a speed of 217 m/s and exits the opposite side with a speed of 109 m/s. If the melon was originally at rest, then what speed will it have as the bullet leaves its opposite side?

Before

Bullet: $m = .025$, $V = 217\ m/s$, $p = 5.425$

Melon: $m = 2.35$, $V = 0$, $p = 0$

$P_{total} = 5.425\ kg\%s$

After

Bullet: $m = .025$, $-V = 109\ m/s$, $p = 2.725$

Melon: $m = 2.35$, $V = \frac{2.7}{2.35} = 1.15\ m/s$

$p = total - p_{bullet} = 5.425 - 2.725 = 2.7$

7. Suppose that you have joined NASA and are enjoying your first space walk. You are outside the space shuttle when your fellow astronaut of approximately equal mass is moving towards you at 2 m/s (with respect to the shuttle). If she collides with you and holds onto you, then how fast (with respect to the shuttle do you both move after the collision?

1- calculate your mass = $\frac{\text{Weight}}{9.8}$

2- calculate friend's momentum = mass (from 1) · 2 m/s

3- calculate speed after collision $V = \frac{P(\text{from 2})}{\text{double mass (you guys stuck tog}}$

1- $m = \frac{200}{9.8} = 20.4\ kg$

2- $p = 20.4 \cdot 2 = 40.8\ kg \cdot m/s$

3- $V = \frac{p}{2m} = \frac{40.8\ kg \cdot m/s}{40.8\ kg}$

$V = 1\ m/s$ no matter what

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Conservation of Momentum

Practice Problems

Useful Equations: $p=m*v$ $p_{before}=p_{after}$

1. What is the momentum of a 1000 kg car traveling at a velocity of 50 m/s?

p

m = 1000 kg

v = 50 m/s

p = mv

1000 · 50

p = 50,000 kg·m/s

2. What is the momentum of a 0.2 kg apple that fell 20 meters in 2 seconds to hit Newton on the head? (hint: First calculate the velocity and then use it to calculate the momentum)

v

d = 20 m

t = 2s

v = at

$\frac{20}{2}$

~~v = 10m/s~~

$v_f = at = v = 19.6$

m = .2kg

v = 10m/s

p = ?

p = mv

.2 · 19.6

p = 3.92 kg·m/s

p = ~~2.4 kg·m/s~~ / ~~39.2~~

3. What is the mass of a baseball with a momentum of 14 kg*m/s and a velocity of 30 m/s?

p = 14 kg·m/s

v = 30m/s

m = ?

$m = \frac{p}{v}$

$= \frac{14}{30}$

= 0.466 ↻

m = 0.5kg

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4. Two students on skateboards are standing still. Jack has a mass of 80 kg and Jill has a mass of 65 kg. They push off of each other and move in opposite directions. Jack has a speed of 3 m/s after the push. What is Jill's velocity after the push?
   a. What is Jack's momentum?

$p = ?$
$m = 80\ kg$
$v = 3\ m/s$

$p = mv$

$80 \cdot 3$

$p = 240\ kg \cdot m/s$

   b. Using Jacks momentum and Jill's mass, calculate her velocity.

$p = 240\ kg \cdot m/s$
$m = 65\ kg$
$V = ?$

$V = \frac{p}{m} = \frac{240}{65}$

$V = 3.7\ m/s$

5. A block of balsa wood whose mass is 0.6 kg is hung from a cord of negligible mass. A bullet whose mass is 0.002 kg is fired into this block at close range with a muzzle velocity of 2,800 m/s and becomes embedded in it.
   a. What is the momentum of the bullet?

$m = .002\ kg$
$v = 2,800\ m/s$
$p = ?$

$p = m \cdot v$
$= .002 \cdot 2800$

$p = 5.6\ kg \cdot m/s$

   b. What is the mass of the piece of wood combined with the bullet?

$m_{wood} = 0.6\ kg$
$m_{bullet} = .002\ kg$

$m_{total} = 0.602\ kg$

   c. Assuming the momentum is conserved what is the velocity of the block of wood after impact?

$p = 5.6\ kg \cdot m/s$
$m = 0.602\ kg$
$V = ?$

$V = \frac{p}{m}$

$\frac{5.6}{.602}$

$v = 9.3\ m/s$